CLAIMS

What is claimed is:

1. An apparatus for screening biological samples for their response to electric fields, comprising:

a container suitable for containing a living biological sample and any associated fluids;

a substrate disposed within the container;

a plurality of independently-addressable electrodes disposed upon the substrate; and

a means of applying differing electrical potentials to the plurality of independently-addressable electrodes for a period of time, wherein different regions of the living biological sample can be cultured in the presence of different selected electric fields and the effects of those different electric fields on a biological function of the living biological sample may be determined.

2. The apparatus of Claim 1 wherein the substrate includes the plurality of independently-addressable electrodes and is integral with a surface of the container.

3. The apparatus of Claim 1 wherein the substrate includes the electrodes and composes a separate structure disposed within the container.

4. The apparatus of Claim 1 further comprising a conductive surface that can be held at ground potential, wherein the plurality of independently-addressable electrodes may be maintained at a plurality of potentials relative to the conductive surface.

5. The apparatus of Claim 1 wherein at least one surface of the container is substantially transparent.

6. The apparatus of Claim 3 wherein the means of applying differing electrical potentials includes at least one active circuit element disposed upon the substrate and connected to at least one of the plurality of independently-addressable electrodes, whereby the electrical

potential of the at least one of the plurality of independently-addressable electrodes may be maintained by the active circuit element.

7. The apparatus of Claim 1 further comprising a porous layer disposed proximate to the plurality of independently-addressable electrodes, whereby cells may be immobilized in selected locations relative to the plurality of independently-addressable electrodes during the period of time.

8. The apparatus of Claim 7 wherein the porous layer includes a material selected from the group consisting of agar, gelatin, cross-linked hydrogels, low-density polyethylene, and porous ceramics.

9. The apparatus of Claim 1 wherein the container includes a plurality of individual chambers and the means of applying includes means for maintaining an independently definable electric field in each of the plurality of individual chambers, whereby contents of each of the plurality of individual chambers may be kept separate from one another.

10. The apparatus of Claim 9 wherein the plurality of individual chambers are disposed upon a common ground plane and each of the plurality of individual chambers contains an electrode at an independently-definable potential relative to the common ground plane.

11. The apparatus of Claim 9 further comprising different contents in at least some of the individual chambers, wherein at least one experimental parameter in addition to electric field may be varied while holding other environmental conditions substantially constant.

12. The apparatus of Claim 3 wherein the substrate includes a porous material having a ground plane disposed upon one surface, the plurality of individually-addressable electrodes disposed upon an opposite surface, and the living biological sample is contained within the porous material.

13. The apparatus of Claim 1 wherein those different electrical potentials are selected from the group consisting of continuous DC, pulsed DC, and AC.

14. The apparatus of Claim 13 wherein the pulsed DC potential has a waveform defining temporal variation.

15. The apparatus of Claim 13 wherein the AC potential is represented by a function selected from the group consisting of a sine wave and a square wave

16. The apparatus of Claim 1 wherein the biological function is selected from the group consisting of: cell growth, proliferation and/or inhibition; platelet adhesion on a surface; gene expression; protein and/or hormone production; cell mobility and/or alignment; healing and/or scar formation; osteoclast, osteoblast and/or macrophage behavior; germination of seeds and/or spores; bacterial growth and/or inhibition; inflammatory responses; release of cell metabolites; and uptake of pharmaceuticals.

17. An apparatus for rapidly screening biological samples for their response to electric fields, comprising:

a container suitable for containing a living biological sample and associated fluids;

a substrate disposed within the container, the substrate including a plurality of independently-addressable electrodes; and

a means of applying differing electrical potentials to the plurality of independently-addressable electrodes for a period of time, wherein different regions of the living biological sample can be cultured in the presence of different electric fields while maintaining other environmental parameters substantially constant and the effects of those different electric fields on at least one biological function of the living biological sample may be determined.

18. The apparatus of Claim 17 wherein the substrate is integral with a surface of the container.

19. The apparatus of Claim 17 wherein the substrate composes a separate structure disposed within the container.

20. The apparatus of Claim 17 further comprising a conductive surface at ground potential, wherein the plurality of independently-addressable electrodes may be maintained at a plurality of potentials relative to the conductive surface.

21. The apparatus of Claim 17 wherein at least one surface of the container is substantially transparent.

22. The apparatus of Claim 17 wherein the means of applying differing electrical potentials includes at least one active circuit element disposed upon the substrate and connected to at least one of the plurality of independently-addressable electrodes, whereby the electrical potential of the at least one of the plurality of independently-addressable electrodes may be maintained by the active circuit element.

23. The apparatus of Claim 17 further comprising a porous layer disposed proximate to the plurality of independently-addressable electrodes, whereby cells may be immobilized in selected locations relative to the plurality of independently-addressable electrodes during the period of time.

24. The apparatus of Claim 23 wherein the porous layer includes a material selected from the group consisting of agar, gelatin, cross-linked hydrogels, low-density polyethylene, and porous ceramics.

25. The apparatus of Claim 17 wherein the container includes a plurality of individual chambers and the means of applying includes means for maintaining an independently-definable electric field in each of the plurality of individual chambers, whereby the contents of each of the plurality of individual chambers may be kept separate from one another.

26. The apparatus of Claim 25 wherein the plurality of individual chambers are disposed upon a common ground plane and each of the plurality of individual chambers contains an electrode at an independently-definable potential relative to the common ground plane.

27. The apparatus of Claim 25 further comprising different contents in at least some of the individual chambers, wherein at least one experimental parameter in addition to electric field may be varied while holding other environmental conditions substantially constant.

28. The apparatus of Claim 19 wherein the substrate includes a porous material having a ground plane disposed upon one surface, the plurality of independently-addressable electrodes disposed upon an opposite surface, and the living biological sample is contained within the porous material.

29. The apparatus of Claim 17 wherein those different electrical potentials are selected from the group consisting of continuous DC, pulsed DC, and AC.

30. The apparatus of Claim 29 wherein the pulsed DC potential has a selected waveform defining temporal variation.

31. The apparatus of Claim 29 wherein the AC potential is represented by a function selected from the group consisting of a sine wave, and a square wave.

32. The apparatus of Claim 17 wherein the biological function is selected from the group consisting of: cell growth, proliferation and/or inhibition; platelet adhesion on a surface; gene expression; protein and/or hormone production; cell mobility and/or alignment; healing and/or scar formation; osteoclast, osteoblast and/or macrophage behavior; germination of seeds and/or spores; bacterial growth and/or inhibition; inflammatory responses; release of cell metabolites; and uptake of pharmaceuticals.

33. A method for determining an optimal electric field for enhancing a biological function

comprising:

placing a living biological sample and optional associated fluids into a container, the container including a substrate having thereon a plurality of independently-addressable electrodes;

applying independently-definable electrical potentials to the plurality of independently-addressable electrodes over a period of time, wherein areas of the living biological sample are exposed to electric fields while being exposed to otherwise substantially similar environmental conditions; and

examining the living biological sample to assess effects of those electric fields on a biological function of the living biological sample, wherein the optimal electric field may be systematically determined.

34. The method of Claim 33 wherein the plurality of independently-addressable electrodes maintain substantially ohmic contact with the living biological sample.

35. The method of Claim 33 wherein the plurality of independently-addressable electrodes are substantially not in ohmic contact with the living biological sample and those electric fields are capacitively coupled to the living biological sample.

36. The method of Claim 33 wherein the plurality of independently-addressable electrodes are substantially not in ohmic contact with the living biological sample and those electric fields are inductively coupled to the living biological sample.

37. The method of Claim 33 wherein at least one surface of the container is substantially transparent and the living biological sample may be visually examined during a period of time during which the living biological sample is exposed.

38. The method of Claim 37 wherein visual examination is performed with an optical microscope.

39. The method of Claim 33 further comprising utilizing a porous layer disposed proximate to the electrodes to immobilize cells in locations relative to the plurality of independently-addressable electrodes during the period of time.

40. The method of Claim 39 wherein the porous layer includes a material selected from the group consisting of agar, gelatin, cross-linked hydrogels, low-density polyethylene, and porous ceramics.

41. The method of Claim 39 wherein the porous layer includes a chemical staining agent and colonies of those cells may be more readily visible.

42. The method of Claim 33 wherein the container includes a plurality of individual chambers and means for maintaining an independently-definable electric field in each of the chambers and contents of each of the plurality of individual chambers may be kept separate from one another.

43. The method of Claim 42 wherein the contents of at least some of the plurality of individual chambers are different and at least one experimental parameter in addition to electric field may be varied while holding other environmental conditions substantially constant.

44. The method of Claim 43 wherein the living biological sample includes pathogenic bacteria and the plurality of individual chambers contain selected concentrations of at least one antibiotic compound.

45. The method of Claim 33 wherein the independently-definable electrical potentials are selected from the group consisting of continuous DC, pulsed DC, and AC.

46. The method of Claim 42 wherein each of the plurality of individual chambers includes a porous, electrically conductive structure in electrical contact with one of the plurality of

independently-addressable electrodes and those electric fields may be applied to a film of bacteria growing on the porous, electrically conductive structure.

47. The method of Claim 33 wherein the selected biological function is selected from the group consisting of: cell growth, proliferation and/or inhibition; platelet adhesion on a surface; gene expression; protein and/or hormone production; cell mobility and/or alignment; healing and/or scar formation; osteoclast, osteoblast and/or macrophage behavior; germination of seeds and/or spores; bacterial growth and/or inhibition; inflammatory responses; release of cell metabolites; and uptake of pharmaceuticals.

48. A method for determining an optimal electric field for enhancing a selected biological process comprising:

placing a living biological sample and optional associated fluids into a container, the container including an electrically insulating structure having thereon a plurality of independently-addressable electrodes;

applying independently-definable electrical potentials to the plurality of independently-addressable electrodes over a period of time; and

examining the living biological sample to assess effects of those electric fields on a biological function of the living biological sample, wherein the optimal electric field may be rapidly determined.

49. The method of Claim 48 wherein the plurality of independently-addressable electrodes maintain a substantially ohmic contact with the living biological sample.

50. The method of Claim 48 wherein the plurality of independently-addressable electrodes are substantially not in ohmic contact with the living biological sample and those electric fields are capacitively coupled to the living biological sample.

51. The method of Claim 48 wherein the plurality of independently-addressable electrodes are substantially not in ohmic contact with the living biological sample and those electric

fields are inductively coupled to the living biological sample.

52. The method of Claim 48 wherein at least one surface of the container is substantially transparent and the living biological sample may be visually examined during a time period during which the living biological sample is exposed.

53. The method of Claim 52 wherein visual examination is performed with an optical microscope.

54. The method of Claim 48 further comprising utilizing a porous layer disposed proximate to the electrodes to immobilize cells in locations relative to the plurality of independently-addressable electrodes during the period of time.

55. The method of Claim 54 wherein the porous layer includes a material selected from the group consisting of agar, gelatin, cross-linked hydrogels, low-density polyethylene, and porous ceramics.

56. The method of Claim 54 wherein the porous layer includes a chemical staining agent and colonies of those cells may be more readily visible.

57. The method of Claim 48 wherein the container includes a plurality of individual chambers and means for maintaining an independently-definable electric field in each of the chambers and contents of each of the plurality of individual chambers may be kept separate from one another.

58. The method of Claim 57 wherein the contents of at least some of the plurality of individual chambers are different and at least one experimental parameter in addition to electric field may be varied while holding other environmental conditions substantially constant.

59. The method of Claim 57 wherein the living biological sample includes pathogenic bacteria and the plurality of individual chambers contain selected concentrations of at least one antibiotic compound.

60. The method of Claim 48 wherein the independently-definable electrical potentials are selected from the group consisting of continuous DC, pulsed DC, and AC.

61. The method of Claim 57 wherein each of the individual chambers includes a porous, electrically conductive structure in electrical contact with one of the plurality of independently-addressable electrodes and those electric fields may be applied to a film of bacteria growing on the porous, electrically conductive structure.

62. The method of Claim 48 wherein the selected biological function is selected from the group consisting of: cell growth, proliferation and/or inhibition; platelet adhesion on a surface; gene expression; protein and/or hormone production; cell mobility and/or alignment; healing and/or scar formation; osteoclast, osteoblast and/or macrophage behavior; germination of seeds and/or spores; bacterial growth and/or inhibition; inflammatory responses; release of cell metabolites; and uptake of pharmaceuticals.